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The Development of an Affective Assessment Instrument Based on Creativity and Critical Thinking on Reaction Rate Material

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Abstract

This study aims to determine the characteristics of the assessment instrument, feasibility, and description of the affective aspects of students in the reaction rate material. The measure affective aspects are creativity and critical thinking attitudes. The research method is research and development (R&D) developed with a 4-D model. The research subject was taken from second-grade Senior High School with a random sampling technique. The initial product of the instrument was content validated by expert judgment, which was calculated using the Aiken formula and construct validity using Confirmatory Factor Analysis. The results showed that the instrument was declared feasible based on the content validity of 0.976 with a good category. The construct validity results stated that 18 fit items from 21 statement items. The description of the affective aspects of students in the reaction rate material from 213 students showed that the average student is in a good category.

Keywords: affective, assessment instrument, the reaction rate

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1. Introduction

Assessment is an important part of the learning process. Besides, the assessment feedback is important in improving student decision-making and learning outcomes (Henderson et al. 2019). In the assessment process, it is very important to determine what type of data is used to track the assessment task (Bayrak, 2021). In line with Chng & Lund (2018) and Inteni et al. (2013), an evaluation must define the object being evaluated, create and determine measurement criteria, and gather and provide information. The 2013 curriculum is a curriculum that includes attitudes, knowledge, and skills intending to develop productive, creative, innovative, and affective students while maintaining attitudes, skills, and knowledge in an integrated manner (Habiby & Sayekti, 2018; Mustafa et al., 2019; Noviar, 2016; Suyanto, 2018).

On the other hand, implementing the affective assessment is rarely applied in schools; other assessments only tend to be daily observations. This phenomenon follows the results of research by Sole and Anggraeni (2017), which found the tendency in schools today: teachers only assess learning achievement or on cognitive aspects, while teachers relatively rarely do psychomotor, especially affective aspects. This condition was also emphasized by Fathayati (2022), who found that teachers who assessed students' affective aspects did not use standard instruments. In other words, assessment is only based on judgment and tends to be subjective. Subjective assessment will make it difficult for the teacher to determine the appropriate follow-up. Thus, to deal with this phenomenon, an instrument accompanied by appropriate and clear criteria is needed to avoid subjectivity in the assessment.

In 21st-century learning, apart from having the responsibility to develop character and literacy, this era is also responsible for developing 4C skills (Collaboration, Communication, Critical Thinking, and Creativity) (Pertiwi & Rizal, 2020). Educators must equip all these subjects with 4C to prepare young people for global citizenship and the workforce (Erdoğan, 2019). These skills are considered a set of skills that students must develop when engaging in global issues, including creativity, communication, collaboration, critical thinking, and problem-solving (Irwanto et al., 2018; Muhlisin et al., 2016; Sanabria & Jesus, 2017). These skills emphasize what students can do with what students know and how to authentically apply what they have learned (Larson & Miller, 2011).

Critical and creative thinking skills are needed by students who plan to work in the 21st century (Verawardina et al., 2020). Critical thinking skills must be familiarized and trained when learning occurs through interaction between teachers and students to realize excellent education. This condition is in line with *Permendikbud* Number 3 of 2020 in article 11 and paragraph 10, which state that the achievement of developing critical thinking skills and creativity helps to realize the learning outcomes of graduates. Therefore, increasing the ability of individuals to solve and understand problems that occur in their environment is done by increasing critical thinking skills and creativity. Hence, critical thinking and creativity are intellectual skills that stand out in the 21st century; because it is considered useful in improving students' problem-solving and decision-making skills through effective collaboration and communication.

Chemistry is one of the subjects in high school, which also requires an assessment of three aspects: cognitive, affective, and psychomotor, especially now that there are 21st-century demands for students' skills. In general, learning the material on the reaction rate is carried out in the classroom to explain theoretically the scope of the concepts contained in the material; it is also accompanied by practical work in the laboratory, especially concerning the factors that affect the reaction rate and collision theory. When the learning process occurs, the teacher often invites students to actively acquire knowledge by asking questions or asking students to ask questions actively. In this way, students are trained to have critical thinking skills about the material discussed. In addition, through learning in class, students are expected to be able to put forward creative and innovative ideas or ideas related to the material being studied. Thus, teachers can create conducive learning conditions, indirectly train students' creative and innovative thinking skills, and improve students' critical thinking skills by asking challenging questions to discuss in learning. Based on this indication, measuring students' attitudes regarding creativity and critical thinking in learning reaction rate material is necessary. This tendency also matches the demands of 21st-century learning to apply skills called 4C. The concept of the 4C competency evaluation model in the 21st-century learning system to date, such as critical thinking skills, is only limited to measuring the cognitive aspects of students. In addition, the evaluation carried out is limited to measuring knowledge through evaluation in the form of a Higher Order Thinking Skill (HOTS) test (Purnawirawan, 2019). Meanwhile, there have not been many comprehensive studies, especially about evaluation instruments to assess the 21st-century learning system in the affective aspect. Therefore, it is important to research to measure the effectiveness of students following the demands of 21st-century learning called 4C skills, which in this study use indicators of creativity and critical thinking.

2. Research Method

This research is a type of development research (research and development). The development procedure used in this study is related to Thiagarajan (1974) or the 4D development model, which consists of four phases: define, design, develop and disseminate—besides, the determination of the subject of this study using random sampling. Subjects were divided into two

parts: trial I and trial II. The data collection technique used for data collection related to expert validation uses validation sheets, and data collection related to the affective nature of students uses self-assessment. The validity used in this research is content validity and construct validity. The results of content validation were calculated using Aiken's V coefficient (Retnawati, 2016), and construct validity were performed by factor analysis using the Confirmatory Factor Analysis (CFA) approach to determine the instrument's stability level using the Alpha Cronbach equation.

$$r_{11} = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum\sigma_i^2}{\sigma_i^2}\right)$$

The other assessment instrument grids can be seen in Table 1.

Table 1. The Affective Assessment Instrument Grid on Reaction Rate Matter

Skill	Indicator	Item Number
Creativity	• Be open to new perspectives.	6
	• Having the nature of trying new things based on the knowledge the students have	18, 4, 15
	• Demonstrate courage in opinion	11, 17, 13
	• Never give up on something	1, 2
Critical Thinking	• Have great curiosity about something	12, 7, 9
	• Ability to find relevant information sources	16, 14, 3
	• Attitude in solving a problem	10
	• Integrating problem-solving solutions	5, 8

The grids are arranged based on the conceptual definitions put forward by experts regarding creativity & innovation skills and critical thinking skills. The opinions of these experts were then synthesized, resulting in an operational definition. Based on the operational definition, the aspects to be assessed are developed. Furthermore, these aspects are described in indicators to make items for evaluating affective aspects related to the reaction rate material. As for each indicator developed in the statement, items on the assessment instrument are arranged randomly.

Some examples of statement items on creativity items: item number 18, "I feel the need to add insight through the internet as a reinforcement of concepts that affect fast reaction rates," and item number 17, "I see problems from various perspectives such as linking reaction rate theory with other theories to find various solutions." As for the statement items on critical thinking, such as in item number 12, "I can conclude the conclusions of the experimental results of factors that affect the reaction rate correctly and following the objectives of the practicum," and item number 5, "I can compare facts and opinions that influence a reaction can take place through the thoughts and results of the assessment.

Table 2. Instrument Sheet Answer Choices

Answer Options	Score
Always	5
Often	4
Sometimes	3
Rarely	2
Never	1

The answer choices used to fill in the affective attitude instrument sheet consist of 5 scales, as shown in Table 2. The students' answers were calculated to determine the high and low results obtained using the ideal mean and standard deviation, as shown in Table 3.

Table 3. The Category of Student Affective Value

Percentage	Criteria
$X > Mi + 1.80\ SBi$	Very good
$Mi + 0.60\ SBi < X \leq Mi + 1.80\ SBi$	Good
$Mi + 0.60\ SBi < X \leq Mi + 0.60\ SBi$	Enough
$Mi + 1.80\ SBi < X \leq Mi + 0.60\ SBi$	Not enough
$X < Mi - 1.80\ SBi$	Very less

The highest ideal score = ∑item x highest score
= 18 x 5
= 90

The lowest ideal score = ∑item x lowest score
= 18 x 1
= 18

Mean Ideal = 1/2 x (90 + 18)
= 54

SBi = 1/6 x (90 – 18)
= 12

From the calculation, the ideal mean is 54, and the ideal standard deviation is 12, so the student response categories are as follows:

Very poor = X < 32.4
Less = 32.4 < X ≤ 46.8
Enough = 46.8 < X ≤ 61.2
Good = 61.2 < X ≤ 75.6
Very Good = X ≥ 75.6

3. Result and Discussion

The product produced in this development research is a self-assessment instrument based on creativity and critical thinking. This instrument is used to measure the affective aspects of students in learning the reaction rate material. Affective assessment is carried out to determine the students' attitudes related to perceptions and behavior. In connection with this study, an affective assessment was carried out, namely assessing the object of attitudes towards the learning process and certain values related to learning to measure the students' competence towards activities carried out in learning activities.

The indicators used are from 4C, namely creativity and critical thinking skills. Creativity is creative thinking that is applied to students so that students are used to being open and responsive in finding or conveying new ideas, ideas, or opinions to others (Yusliani et al., 2019). Ennis in Rear (2018) defines critical thinking as reasonable, reflective, and focused on deciding what to believe or do.

The assessment instrument is equipped with filling instructions, statement items, and answer choices. 4C is used as the basis for measuring affective aspects in this study because of the concepts of the 4C competency evaluation model in the 21st-century learning system. Also, the researcher searched the development of cognitive assessment for literature. At this time, there has not been much comprehensive study, especially concerning instruments in the affective aspect of learning chemistry material and reaction rate material; even less, 4C is a skill in a 21st-century learning system that needs to be assessed. This condition follows Prihadi (2017), which states that 4C skills support the 21st-century learning system. The final product consists of a grid accompanied by a self-assessment sheet.

The instruments developed were tested for content validity and construct validity. The data to calculate the level of content validity was obtained from the assessment of 6 validators: two lecturers and four educational practitioners. After that, the instrument statement items that had Aiken's V Content Validity Index greater than or equal to 0.78 according to the provisions of Aiken were tried out to be filled in by the research subjects. Overall, the results of content validation by experts at the stage of developing the assessment instrument were based on calculations using the Aiken formula; the average statement items obtained a coefficient of 0.976. This data shows that the overall quality of the resulting assessment instrument, in terms of its content validity, is good, and all items conform with the indicators. The next step is to do trial I to see the validity of the instrument construct. Regarding construct validity, the confirmatory factor analysis results using the Lisrel Program's help on creativity affective totaling ten statement items can be seen in Figure 1. In the Lisrel program, item names cannot be named too long, so the ten items measured creativity are abbreviated using the term CRE.

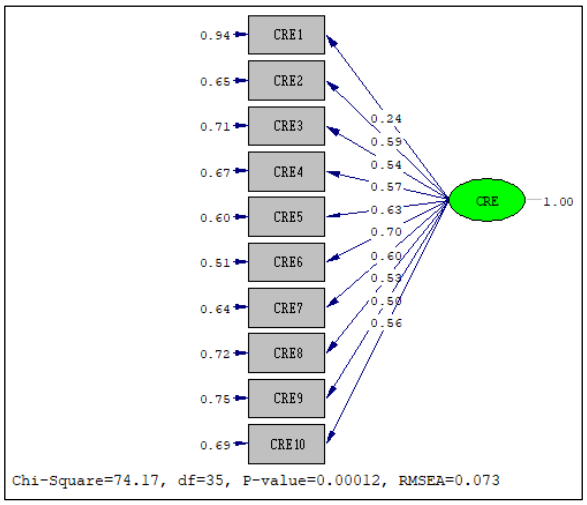

Figure 1. Standardized Solution Creativity

Based on Figure 1, not all statement items have a loading factor > 0.35. These findings align with what Keith (2015) stated, that when the model is not suitable, someone may be able to increase the fit by freeing the parameters in the model. Also, freeing these parameters will reduce the model's degrees of freedom (Parsimony) and increase $\Delta\chi 2$ to a certain degree. Besides, one item has a loading factor value of less than 0.35, namely the CRE1 item, so the researchers omitted CRE1. All items have a t-value > 1.96, but the chi-square ($p > 0.05$) and RMSEA (Root Mean Square Error of Approximation) < 0.05 do not meet the criteria. This category shows that the model built is not fit with the data. Therefore, a modification of the model is required. Hence, the unfit results caused the researchers to modify the model by removing items with a loading factor below 0.35; however, after removing CRE1 items, they had not produced good goodness of fit.

On the other hand, modifications were made by considering the index modifications suggested by Lisrel. The researchers took advantage of this suggestion to improve the model fit by connecting CRE3 with CRE4 and CRE6 with CRE10. The modification results suggested by Lisrel are shown in Figure 2. Based on the results of these modifications, it shows that the goodness of fit is good because chi-square = 0.07431 ($p > 0.05$), RMSEA = 0.045 (RMSEA <0.05).

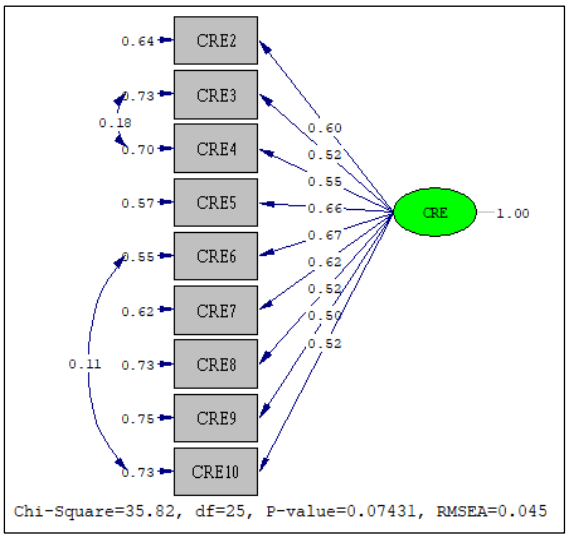

Figure 2. The Revision of Standardized Solution Creativity

In addition, a significant t-value was obtained; the t-value was > 1.96 for all items. This data shows that these items are valid for measuring constructs on creativity. As for the results of the analysis of critical thinking skills that were measured, there were 11 statement items. Figure 3 shows the magnitude of the loading factor for each item. In critical thinking items, item names are abbreviated as CRI, so the researchers write critical thinking items, totalling 11 items, and written with CRI1-CRI11.

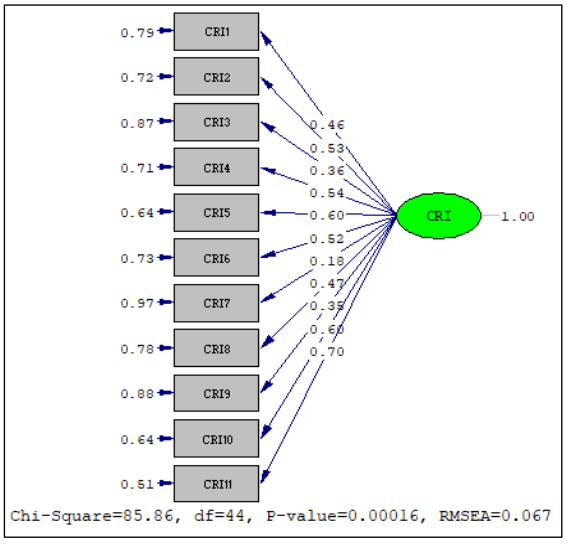

Figure 3. Standardized Solution Critical Thinking Skill Competency

Based on Figure 3, not all statement items have a loading factor > 0.35, as found in CRI7

and CRI9 items; but all items have a t-value > 1.96. The p-value obtained is below 0.05, and the RMSEA is greater than 0.05, indicating that the model built does not fit the data. Therefore, a modification of the model is required. Items with a loading factor below 0.35 were excluded: CRI7 and CRI9 items. However, after removing these items, it has yet to produce a good goodness of fit. Modifications were made by taking into account the index modifications suggested by Lisrel. The researchers used these suggestions to improve the model fit by connecting CRI4 with CRI6. The modification results as suggested by Lisrel are shown in Figure 4.

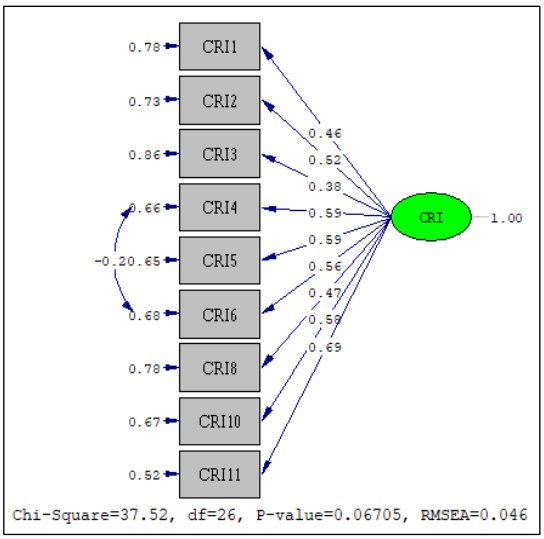

Figure 4. Standardized Solution Critical Thinking Skill Revision

Based on the results of these modifications, it shows that the goodness of fit is good because of the chi-square = 0.06705 (p > 0.05), RMSEA = 0.046 (RMSEA <0.05). In addition, a significant t-value was obtained; the t-value was > 1.96 for all items. This data shows that these items are valid for measuring constructs on critical thinking skills.

Besides, out of 21 statement items originating from ten creativity items and 11 critical thinking items were analyzed using confirmatory factor analysis; consequently, only 18 items were fit. It was caused by one item that fell from creativity & innovation, namely CRE1 and 2 of critical thinking skills: CRI7 and CRI9. The next step was to estimate the reliability of the instrument. The reliability used in this instrument was using Cronbach's Alpha coefficient. To find out if the data is reliable, then the calculation of r count > r table. Based on the distribution table, the r-value table had a significance of 1% with a number of N 18, which is 0.59. Based on the results of the reliability test that had been carried out, the Cronbach Alpha coefficient is 0.83. After the instrument was declared valid in terms of content and construct, then trial II was carried out to find out the affective description of students. The results of the affective measurement of students carried out in two high schools in Palembang in trial II can be seen in Figure 5. Referring to the final product that had been produced with the support of quality evidence, it is very helpful to add references for teachers regarding examples of assessment instruments that can be used in conducting assessments based on the 2013 curriculum. Hence, it has been proven theoretically and empirically of good quality and can also be used by teachers as a reference for conducting research.

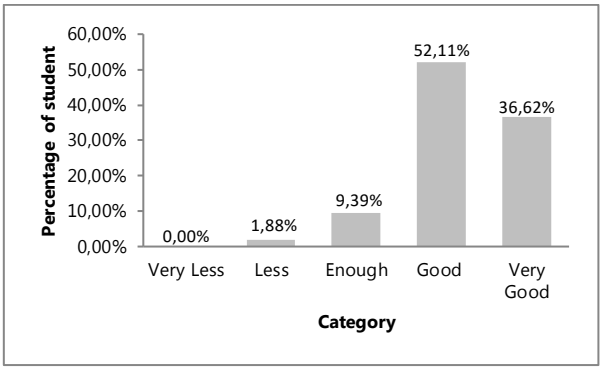

Figure 5. Student Affective Measurement Results

Based on the description of affective achievement in Figure 5, information is obtained that the average student has affective. The description of the affective aspects of students in learning the reaction rate material in this study was obtained from the application of instruments that were empirically proven to be of good quality. The data of the application of the instrument were empirically followed up by interpreting the score using the established interpretation method. Based on the results of the average

assessment of students who have good affective with a percentage of 52.11% of 213 students. This proves that the assessment instrument developed can measure the affective aspects of learning the reaction rate of students well.

The rate of reaction is the decrease in the amount of reactants for a unit of time or an increase in products for each unit of time (Smart Solutions Team, 2017). The law of the reaction rate relates to the initial concentration of the reactants (Sudarmo, 2017). The reaction rate has a constant which is highly dependent on the reaction temperature. Learning about the reaction rate material is not only carried out in the classroom, it is also accompanied by practicum in the laboratory. This is in line with what was stated by Mudhakiyah (2022), Reaction rate material is also one of the materials that is often practiced in learning activities. The magnitude of the application of reaction rate material in practicum activities and theoretical learning certainly needs to be balanced with the availability of appropriate assessment instruments in assessing student competence, such as the attitude of students in asking questions in the ongoing learning process or in practicum when conducting experiments and linking the results of their observations with understanding and knowledge of the concept of reaction rate.

In this study, the 4C skills used were only creativity and critical thinking skills. Creativity refers to creating new ideas that contribute to certain entities; the concept of creativity has a broader meaning, including creating new ideas or better ideas related to processes, products or services (Edwards-Schachter, 2018). Critical thinking is a mental process in which individuals require to be active and skilled at conceptualizing, applying, analyzing, synthesizing, and evaluating information to reach answers or conclusions (Changwong et al., 2018). In the ongoing learning process, students' creative attitudes and critical thinking often appear unconsciously. Therefore, using standard instruments is important to measure students' creativity and critical level. On the other side, Purnawirawan (2019) conducted research which also examined the 4C skills with the title, "Development of the 4C Assessment Instrument (Creativity, Critical Thinking, Communication, and Collaboration) for the 21st Century Learning System in Teaching the Productive Fields of Vocational High Schools". This study aims to develop a 4C assessment instrument in the productive field of Graphic Design in Vocational High Schools. Also, research was conducted by Dewi (2021) with the title "Development of an Assessment Instrument for 4C Learning and Innovation Skills in Science Learning for Fifth Graders of Elementary School". This study aims to develop an assessment instrument for learning and innovation skills (4C) in the fifth-grade science subject in elementary school. From those two studies related to the 4C skills, the researcher found those findings were very minimal, even those researches did not aim at measuring the affectiveness of students at the high school level, especially regarding the reaction rates. Therefore, it is necessary to research 4C skills in other chemical materials besides reaction rate materials for further research. For the assessment to be carried out comprehensively, it can describe students' competence in measurements of cognitive and affective aspects, and even research on psychomotor aspects can be carried out.

4. Conclusion

The assessment instrument developed has characteristics that can measure the affective aspects of the reaction rate material. The developed instrument is feasible to use as indicated by: content validity by expert judgment obtaining the Aiken index of 0.976, construct validity proven by confirmatory analysis by obtaining 18 fit items, instrument reliability obtaining Cronbach's Alpha coefficient of 0.83, and affective descriptions of 213 participants students get a percentage of 52.11% in the good category. Veloo et al. (2015) state that students with a good learning attitude can improve their learning. The assessment instrument developed has characteristics that can measure the affective aspects of the reaction rate material. The developed instrument is feasible to use as

indicated by content validity by expert judgment obtaining the Aiken index of 0.976, construct validity proven by confirmatory analysis by obtaining 18 fit items, instrument reliability obtaining Cronbach's Alpha coefficient of 0.83, and affective descriptions of 213 participants students get a percentage of 52.11% in the good category. Veloo et al. (2015) state that students with a good learning attitude can improve their learning. Hence, it is recommended that future researchers develop the instrument and the psychomotor aspects that do not only measure the affective aspect of the reaction rate material; but also, other chemical materials.

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